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ABSTRACT

Electronic Portal Imaging Devices (EPID) are used for the assessment of the geometric accuracy[1, 2] during the radiation therapy process. EPID is also used like a major detector to test performances of the linear accelerator used for the treatment. Therefore, the quality control of portal images[3, 4, 5, 6, 7] is essential for this task.

Software tools[8] that are capable to perform an automatic quality control of EPID images in terms of spatial resolution, low level contrast, geometric distortion linearity, pixel size… are presented in this paper. Furthermore, a general concept of numerical 3D modeled Digital Test Objects[9] (DTO) in order to produce EPID images is also presented. These DTOs are aimed to reproduce the composition and the geometry of physical objects as well as their acquisition procedure.

Keywords: ALG, METER, SIM, OTHER.

PREFERRED PRESENTATION TYPE

Oral presentation.

1. DESCRIPTION OF PURPOSE

The purpose of our work is to make the process of EPID images quality control faster, more precise and more complete. Therefore, the software tools QUALIMAGIQ-EPID[8, 10] that are capable to perform an automatic analysis are being developed. In order to evaluate the performances of this software, a new method using digital phantoms (DTO) has been proposed. These DTOs allow reproducing the exact geometry and physical compositions of the main physical test objects available on the market, especially those used for the EPID quality control.

2. MATERIALS AND METHODS

The physical test object proposed by PTW[11] is used for EPID images quality control. This phantom covers all essential quality parameters in one image. It allows evaluating geometric distortions, spatial resolution, contrast, signal linearity and uniformity. The EPID-PTW phantom is composed from different metal inserts (aluminum or copper) arranged on a plastic matrix.

A more simplified physical test object is used for the geometrical controls. It is composed from a 5mm diameter radio-opaque ball (Tungsten Carbide) fixed on the couch or on the gantry. It allows evaluating the shift errors of the portal imaging device during its vertical movement and gantry rotation.

Moreover, a pewter square metallic frame with 150mm side lengths is used to control pixel length and EPID's sensible source-surface distance.

For the quality control of the images, the first step of the control process is the image registration that allows to find the position and orientation of the real (physical) phantom. Several regions of interest of different shapes with specific positions and sizes are automatically detected in the images in order to acquire the measurements (mean and standard deviations). All parameters are then automatically evaluated and controlled.

To perform a geometric quality control, our algorithm uses a convolution method in order to detect automatically the ball position with respect to the flat panel detector. Positions for different images are finally compared.

For pixel length evaluation, metallic frames on the images are automatically detected and the lengths of each size are calculated and compared with the real lengths of the phantom.

Beam lengths are finally detected and compared with real values précised by the user.

These different algorithms are controlled by using digital phantoms. The purpose of this work is to generate 3D objects which simulate the physics of the acquisition and the geometry of the phantom. The acquisition process simulation consists of modeling a source point and a flat panel sensor. Different shapes (spheres, boxes, cylinders and rings) representing physical objects are simulated. The size and the linear absorption coefficient of each object is précised by the user.

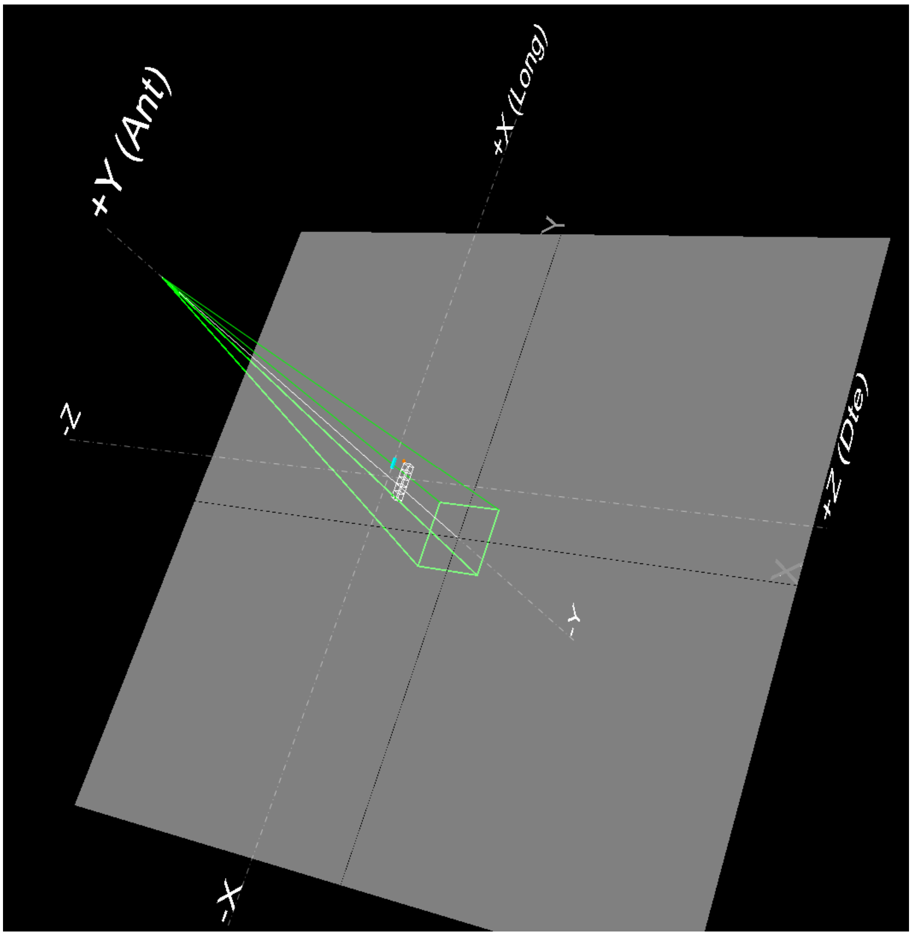

Fig. 1. A three-dimensional numerical simulation of the acquisition process. Source and sensor are shown, as well as different shapes (boxes, cylinder and a sphere).

2D portal images are finally produced in DICOM format. Many parameters interfere in order to calculate final pixels intensities: rays-objects intersection, object's linear absorption coefficient and the inverse square law…

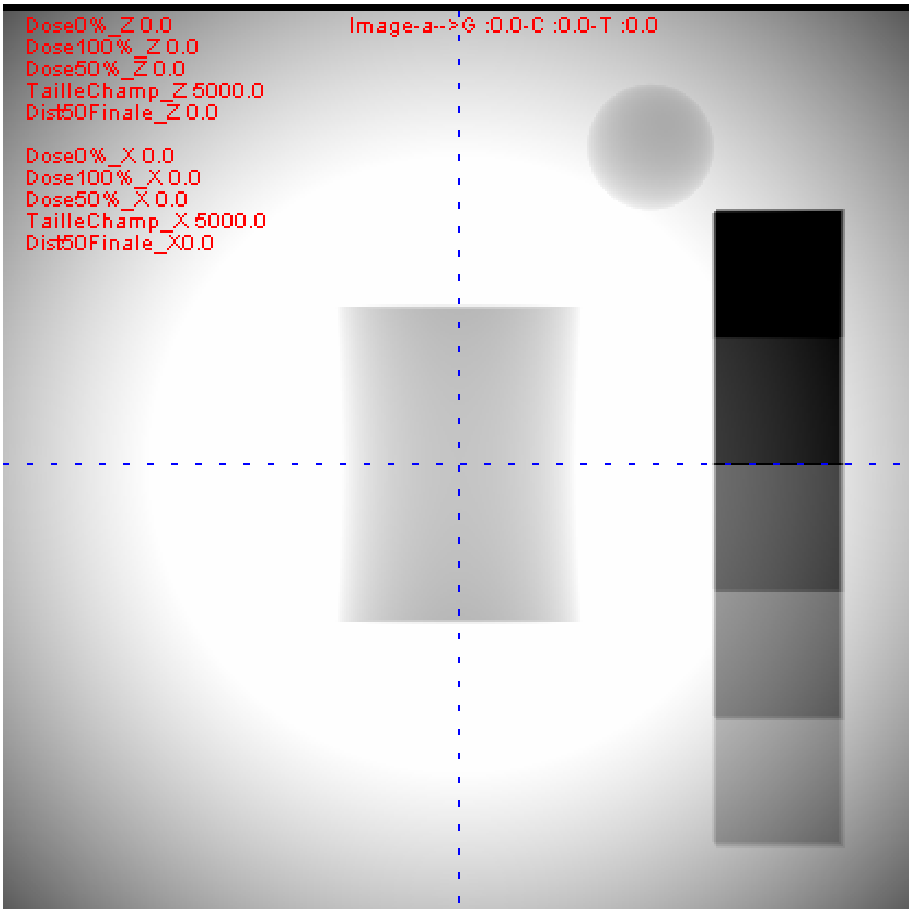

Fig. 2. Generate 2D DICOM image by using the above 3D scene.

Knowing the exact geometry and physical composition of these DTOs, an automatic quality control using our algorithms is then applied, and all parameters are evaluated. The introduced parameters are then compared with the estimated ones in order to assess the accuracy of the algorithms.

3. RESULTS

Software tools for the automatic analysis of the EPID images are approved to be important tools which are easy to use and which perform an automatic quality control at reduced time and improved control precision.

Digital phantoms with various calibrated geometric and physical properties have been generated and controlled. Results issued from the application of our algorithms showed high level of precisions. The possibility of generating DTOs with different characteristic allows determining the effect of each characteristic on every controlled parameter as well as testing the limits of these algorithms.

4. BREAKTHROUGH WORK

Software tools that are capable to perform an automatic analysis of EPID images are being developed. All parameters are evaluated automatically without user interference.

Furthermore, the technique of generating digital phantoms proves to be an important technique allowing the evaluation of these software tools in medical imaging. These DTOs can also be used to design and simulate new physical test objects and to evaluate their performance and objectives.

REFERENCES

1. LutzW, Winston K R MalekiN. A system for stereo tactic radio surgery with a linear accelerator, Int. J. Radio. Oncol. Biol. Phys. 14 373-81, 1988.
2. Winkler P., Bergmann H., Stuecklschweiger G., Guss H. Introducing a system for automated control of rotation axes, collimator and laser adjustment for a medical linear accelerator. Physics in Medicine and Biology, Volume 48, Number 9, pp. 1123-1132.
3. P. Munro, ‘‘Portal imaging technology: Past, present and future,’’ Semin. Radiat. Oncol. 5, 115–133, 1995.
4. Low D.A., Klein E.E., Maag D.K., Umfleet W.E., Purdy J.A., Commissioning and periodic quality assurance of a clinical electronic portal imaging device, Int. J. Radiation Oncology Biol. Phys. 34(1), p.117, 1996.
5. Herman MG, Abrams RA, Mayer RR. Clinical use of online portal imaging for daily patient treatment verification. Int J Radiat Oncol Biol Phys, 28 : 1017-1023, 1994.
6. Low DA, Klein EE, Maag DK, Umfleet WE, Purdy JA. Commissionning and periodic quality assurance of a clinical electronic portal imaging device. Int J Radiat Oncol Biol Phys, 34: 117-123, 1996.
7. Herman MG, Balter JM, Jaffray DA, et al. Clinical use of electronic portal imaging: report of AAPM Radiation Therapy-Committee Task Group 58. Med Phys, 28: 712-737, 2001.
8. http://www.qualiformed.com
9. T. Torfeh, S. Beaumont, JP. Guédon, E. Denis. Evaluation of two Software Tools dedicated to an Automatic Analysis of the CT Scanner Iimage Spatial Resolution. IEEE, Engineering in Medicine and Biology Society. Lyon-France, August 2007.
10. T. Torfeh, S. Beaumont, JP. Guédon, N. Normand & E. Denis, “Software Tools Dedicated for an Automatic Analysis of the CT Scanner Quality Control’s Images”. Conf. Medical Imaging, San Diego, February 2007.
11. Schmidt, Decker, Winkes, Rittler, Kretner and Herbig. EPID QC Phantom; Freiburg - Germany